International Journal of Agricultural
Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 6, Issue 1, Feb 2016, 105-112

PERFORMANCE STUDIES ON POWER OPERATED CHAFF CUTTER WITH PARAGRASS (*BRACHIARIAMUTICA*)

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ABSTRACT

India ranks first in the livestock population of 485 million as per livestock census (2008. Occasionally farmers chop the fodder into smaller sizes, using sickles or sharp knives for feeding the animals which may increase the utilization and digestion ratio. To meet the growing livestock farms demand, use of high efficiency, safe forage chaff cutters are the need of the hour. Traditional fodder chaff cutters are not suitable for fast and large scale chopping. The power chaff cutters alone could serve as alternative under present labour crisis particularly in India. Optimization of working parameters is highly essential in improving the efficiency of chaff cutters. Hence, a study was taken up to evaluate 'SwarajToka' make power operated chaff cutter under three speeds (0.1,0.12 and 0.14 m/s) with two different blades (Straight edge and Serrated edge) for para grass at different levels of moisture content(63.13%, 56.25 % and 51.3%) at College of Agricultural Engineering, Bapatla. It was found that the efficiency increased with the increase in cutting speed and moisture content. The maximum efficiency of 85.1 % was obtained at the maximum speed of 0.14 m/s at maximum moisture content of 63.13% whereas the minimum efficiency of 48.5% was obtained at the speed of 0.1m/s at a moisture content level of 51.3%. The efficiency was more in serrated edge of 85.1% than in straight edge of 66.4%. The maximum and the minimum capacity of chaff cutter obtained were 0.471 Mg h^{-1} and 0.309 Mg h^{-1} respectively. A maximum length of cut was observed to 2.24 cm at a moisture content of 51.36% and a minimum length of cut was observed to be 1.84 cm at 63.13% moisture content in case of serrated edge blade while a maximum length of cut was observed to be 2.52 cm and 2.24 cm at 51.36% and 63.13% moisture content of chaff for straight edge blade.Finally, it was concluded that the maximum efficiency of chaff cutter can be obtained at highest moisture content of Para grass, highest speed of chaff cutter with serrated edge blade and with an inverse relationship between chop length and moisture content.

KEYWORDS: Chaff Cutter, Fodder, Length of Chaff, SwarajToka and Efficiency

Received: Dec 17, 2015; **Accepted:** Jan 07, 2016; **Published:** Jan 18, 2016; **Paper Id.:** IJASRFEB201615

Original Article

INTRODUCTION

Animal feedstuff is higher essential for the rearing of the animals to meet the increasing demand for animal protein, milk hides, skin and other products in the increasing population scenario. The animal rearers collect crop residues to feed the animals directly.Occasionally farmers chop the fodder conventionally into smaller sizes, using sickles or sharp knives for feeding the animals. In order to ensure good animal welfare, animals must be able to fulfil their physiological and ethological needs.The animals can utilize not only theleaves, but also the stovers, if they are reduced into smaller sizes. Cutting the stovers of the crop residues increased the voluntary intake of cattle by 6 to 9% (Minson, 1990).The chopped forage may increase the utilization and digestion ratio.

Also silage can improve the quality and the taste agreeableness of forage. Further the green feed could be stored for a longer period of time minimising the nutrition loss. The growth in number of livestock farms in the country demands for high quality forage with less power consumption.

To meet the growing livestock farms demand, a high efficiency, safe forage processing chaff cutters are the need of the hour. An increase in the cutting speed results in the maximum efficiency and chopper capacity by using the serrated edge shape blades (Ismail FouadSayad-Ahmed et al., 2009.). Energy consumption can be decreased by increasing the cutting speed (Elfatihet A. et al., 2010.). Using the traditional methods of cutting the crop residues is very cumbersome and labour oriented. The government of India programmes like “GopalaMitra” and the emerging dairy farms step up the “White revolution” in the country. The growing milking animal strength utilizes large quantity of fodder. The power chaff cutters alone can serve the purpose of growing livestock farmsunder large quantity consumption under a critical labour crises prevailing in the country. Keeping all these in view, the present study was taken up to evaluate apower operated chaff cutter under three different speeds, three moisture contents of grass and working blades and finally quality of chopped fodder. (Barrington et al., 1971.) Stated that the length is adjusted by changing the speed of feed mechanism or number of knives on the cutter head. (Hennen et al., 1971) He reported that the energy requirements at normal feed rates ranged from 1.0 to 1.5 kWh $Mg^{-1}$for a 13 mm length of cut with corn silage at 60 to 80% moisture content and 1.5 to 2.0 kWh Mg^{-1} for a 6 mm length of cut with mature corn silage 40 to 60 % moisture content. (Kepner et al. 1982)stated that energy is related to the length of cut. The chopping energy was inversely proportional to the length of cut for short cuts. (Metwelli et al., 1995)concluded that by increasing the moisture content of chaff, the cutting efficiency of chaff cutter increased, and the power required was decreased. (Marey S. A. et al., 2007)They concluded that the decreasing moisture content, increase in number of knives and speed ratio gave more fine bagasse which produces a high quality silage.(Arif et al., 1999)mentioned that the cut length of residues depends on the feeding drum speed moisture content and knives clearance.

MATERIALS AND METHODS

Already available “SwarajToka” make power operated chaff cutter most popular in the study region i.e. Bapatla surrounding of Guntur Dist., Andhra Pradeshwas evaluated for its capacity, efficiency, energy consumption at three moisture levels with three cutting speeds, three moisture contentsand with two types of blades.The variety used for chopping fodder was Para grass (Brachiariamutica) which is the duration of the fodder was 30 days.The fodder height was 85 cm to100 cm. The moisture content of fodder was calculated using a hot-air oven on dry basis. The moisture content of fodder varied between 50%to 65% during the study period.The specifications of chaff cutter chosen for the study is given in Table1.

Table 1: Specifications of the Power Chaff Cutter

Sl. No.	Parameter	Power Operated
1	Make	SwarajToka
2	No of Rollers	03
3	No of Blades	02
4	Width of Mouth	21 cm (or) 9"
5	Drive Wheel	C.I, V- Type
6	Power Required	2 hp, Single phase electric motor
7	Out Put	400 - 500 Kg h^{-1}
8	Approx. Weight	150 Kg

METHODOLOGY

The performance of the chaff cutter was studied at three different speeds by adopting three different diameter driving pulleys.The three different cutting speeds obtained are (0.1m s^{-1}, 0.12m $s^{-1}$and 0.14m s^{-1}). Two types of cutting knives (serrated & straight edge) are adopted on the fly wheel cutter head. The fodder used for cutting was at three different moisture levels (63.13%, 56.25%, and 51.36%). When the chaff cutter is operating the fodder is fed uniformly. A fodder sample size of 5 kg was used for chopping. Every experiment is replicated thrice. The fodder at particular moisture content, the cutting head speed is measured with a Tachometer. The time required for complete chopping of a sample fodder (5 kg) was recorded with a stopwatch. A sample of unit weight was taken from the chopped material to find the length of cut and quality of fodder. The energy required for chopping of every sample was recorded from the Energy meter.

Performance Parameters of Chaff Cutter Evaluation

The performance study was carried out at College workshop by procuring para grass grown from nearby farmer's field.

- **Capacity of Chopper**

The theoretical capacity T_t, in Mg h^{-1}, was calculated using the relationship:

$T_t = 6 \times 10^{-9} \times \rho \times A \times L \times N \times R$, Mg h^{-1}

Where, ρ -Density of materials it passed between the feed rolls, kg m^{-3}, A = Throat area, cm^2, L-Length of cut, mm, N -Number of knives on cutter head, R = Speed of cutter head, rpm.

- **Actual Capacity of Power Chaff Cutter**

The capacity was measured by weighing chopping material output over period of time. The time required for chopping the sample of fodder was recorded.

Actual capacity was expressed in terms of Mg h^{-1}.

$$\text{Actual capacity, Mg } h^{-1} = \frac{\text{Weight of fodder}}{\text{Time required for chopping the fodder}}$$

- **Machine Efficiency**

Machine efficiency was calculated according to following equation:

$$\eta = \left(\frac{\text{Actual capacity}}{\text{Theoretical capacity}}\right) \times 100$$

- **Energy Consumption**

The energy consumed for complete chopping of the sample of fodder was recorded from the energy meter. The time required for complete chopping of the sample fodder was recorded. The energy required was estimated by using the following equation.

$$\text{Energy requirements (kW h ton}^{-1}) = \frac{\text{Power requirement,kW}}{\text{machine productivity,ton h}^{-1}}$$

RESULTS AND DISCUSSIONS

The results of performance evaluation under three different speeds, three different moisture contents of grass and two types of blades as mentioned in the previous section is summarised in Table 2.

Table 2: Performance Evaluation of Chaff Cutter

Sl. No.	Moisture Content, (%)	Cutting Speed, (m s^{-1})	Average Chopping Length,(cm)	Average Energy Consumption, (kWh Mg^{-1})	Average Actual Capacity, (Mg h^{-1})	Average Efficiency, (%)
Serrated Edge Blade						
1	63.13	0.10	1.84	4.3	0.406	56.2
		0.12	1.6	5.0	0.439	61.1
		0.14	1.56	6.14	0.471	85.1
2	56.25	0.10	2.0	4.9	0.364	52.1
		0.12	1.78	5.4	0.419	66.8
		0.14	1.75	7.4	0.440	78.2
3	51.36	0.10	2.24	6.83	0.329	48.5
		0.12	2.1	7.2	0.364	51.1
		0.14	1.9	10	0.411	74.6
Straight Edge Blade						
1	63.13	0.10	2.24	4.7	0.384	49.3
		0.12	1.78	5.27	0.431	55.8
		0.14	1.6	6.5	0.457	59.8
2	56.25	0.10	2.36	5.2	0.449	42.1
		0.12	2.28	5.8	0.392	48.2
		0.14	2.19	7.8	0.423	60.8
3	51.36	0.10	2.52	7.5	0.309	39.4
		0.12	2.39	8.2	0.338	42.2
		0.14	2.22	11.8	0.368	66.4

The performance of chaff cutter under different parameters were plotted individually and discussed detail in the following subsections.

- **Effect of Cutting Speed on Efficiency of Chaff Cutter**

The chaff cutter was operated at three different cutting speeds 0.1 m s^{-1}, 0.12 m s^{-1}, and 0.14 m s^{-1} by changing the driving pulleys of the motor. It could be observed that the efficiency of chaff cutter was increased with increase in cutting speed in all conditions tested (Figure 1). Maximum efficiency obtained was 85.1% at 0.14 m s^{-1} while minimum efficiency obtained was 39.4% at 0.1 m s^{-1} cutting speed. The efficiency of chaff cutter was found higher when it was operated at high cutting speed under constant fodder moisture content.

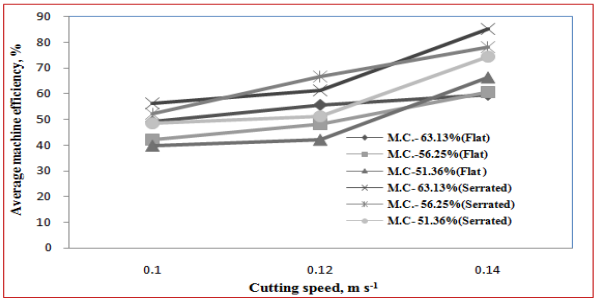

Figure 1: Effect of Moisture Content of Paragrass, Type of Blade and Cutting Speed on Efficiency of Chaff Cutter

- **Effect of Moisture Content of Paragrass on Efficiency of Chaff Cutter**

For the variability of different conditions tested, the efficiency of chaff cutter rangedfrom 39.4% to 85.1%. The efficiency of chaff cutter increased with increase in moisture content of fodder. When the moisture content of fodder was changed from 51.36% to 63.13%, the efficiency increased from 74.60% to 84.51% for a serrated edge blade. While for a flat edge blade for the moisture contents between 51.36% to 63.13%, the efficiency of chopping increased from 39.4% to 59.8%. Hence it is evident that the chaff cutter efficiency is much better when it is operated with the green fodder rather than dry fodder.

- **Effect of Type of Blade on Efficiency of Chaff Cutter**

The types of cutting blades (straight or flat edge blade and serrated edge blade) were arranged on the cutter head individually and the experiments were conducted. The maximum efficiency of 85.1% was observed with serrated edge blade while 66.5% efficiency was observed with plain edge blade which evidently lowers than the serrated edged blade.

- **Effect of Different Parameters on the Capacity of Chaff Cutter**

The capacity of chaff cutter was mainly affected by the cutting speed, moisture content of fodder and the type of cutting blade used on the cutter head. The maximum and the minimum capacity of chaff cutter obtained were 0.471 Mg h^{-1} and 0.309 Mg h^{-1} respectively. When the cutting speed was changed from 0.1m s^{-1} to 0.14 m s^{-1} the capacity increased from 0.406 Mg h^{-1} to 0.471 Mg h^{-1} at 63.13% moisture content(Figure 2). The capacity of chaff cutter increased with increase in moisture content of fodder. The maximum capacity of chaff cutter was found to be 0.471 Mg h^{-1} at 63.13% moisture content, 0.440 Mg h^{-1} at 56.25% and 0.411 Mg h^{-1} for serrated edge blade. Similar trend was observed in the case of straight edge blade also.A maximum capacity of 0.471 Mg h^{-1} was observed when a serrated edge blade was used, where as a capacity of 0.457 Mg h^{-1} only was recorded in the case of straight edge blade.

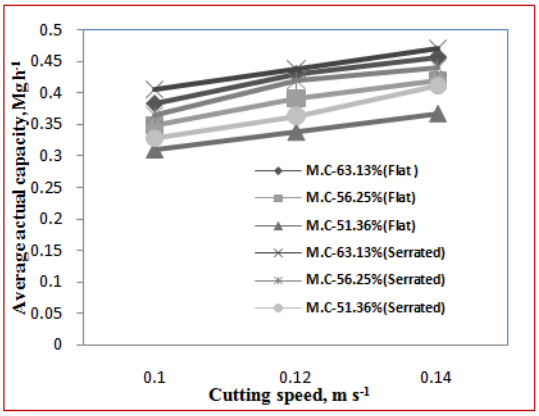

Figure 2: Effect of Various Parameters on the Capacity of Chaff Cutter

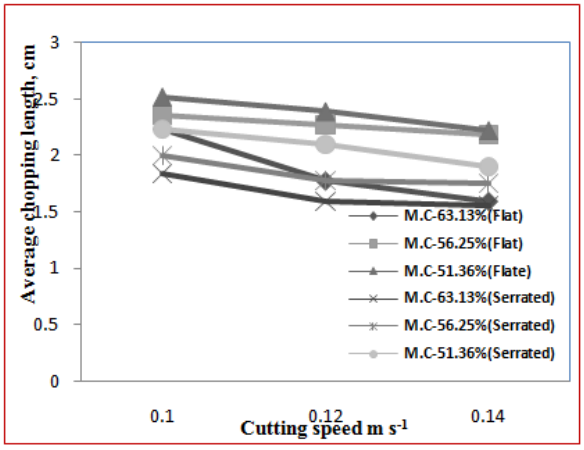

Figure 3: Effect of Different Parameters on Chopping

Length of Chaff Cutter

- **The Effect of Various Factors on the Chopping Length of Fodder**

It was observed that the length of cut of chaff increases with decrease in moisture content of chaff. A maximum length of cut was observed to 2.24 cm at a moisture content of 51.36% and a minimum length of cut was observed to be 1.84 cm at 63.13% moisture content in case of serrated edge blade while a maximum length of cut was observed to be 2.52 cm and 2.24 cm at 51.36% and 63.13% moisture content of chaff for straight edge blade(Figure 3). This is because the crushing and feeding time of green fodder by the spiked feeding rollers is more than the dried fodder. The dried fodder is fed to cutting mechanism easily and leads to higher length of cut.

CONCLUSIONS

The type of evaluation performed in this study would enable a researcher to optimize the working conditions of a power operated chaff cutter for recommending in filed large scale chop production. The present study revealed that the maximum efficiency was 85.1% attained at 0.14 m s^{-1} with serrated edge blade. The efficiency of chaff cutter increased with increase in moisture content of fodder.The maximum value of chopper capacity was found to be 0.471 Mg h^{-1} at 61.5 %for serrated edge blade. It was observed that chop length varied inversely with moisture content of the grass directly with cutting speed. A minimum length of cut found was 1.56 cm when a serrated blade was adopted.The chaff cutter consumed low energy 4.3 $kWhMg^{-1}$ when a serrated edge blade was adopted for cuttingwhich was proportional to the cutting speeds. The energy consumption of the chaff cutter varied directly with moistre content of chaff used.

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